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THE NUTRITION AND MANURING OF SOFT FRUITS

by

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FOREWORD

In 1933 the Bureau bound together and re-issued two papers by Dr. T. Wallace on the manuring of deciduous fruit trees.*

The demand for this publication still continues and in addition enquiries are often received as to the proper manuring of small trees.

By the courtesy of the Council of the Royal Horticultural Society and by the kind permission of the author the Bureau is now able to issue a further article by Dr. Wallace dealing with the manuring of small fruits. The article is a paper read at the Cherry and Soft Fruits Conference held by the Royal Horticultural Society in London, July 16 and 17, 1935, and was originally published in the report of that Conference.†

* Problems of Fruit Tree Nutrition—Possible Lines of Approach. Imp. Bur. Fruit Prod. Tech. Comm. 4, 1935, price 2*s*.

† Cherries and Soft Fruits, Varieties and Cultivation in 1935. London: Royal Horticultural Society, Vincent Square, S.W. 1., price 6*s*.

THE NUTRITION AND MANURING OF SOFT FRUITS.

By Dr. T. Wallace
(Long Ashton Research Station, University of Bristol).

In the present paper it is proposed to confine the discussion to the following classes of soft fruits : Gooseberries, Black and Red Currants, Raspberries, Loganberries, Blackberries and Strawberries ; of these Loganberries and Blackberries will be dealt with briefly since experimental data on these fruits are negligible and definite conclusions based on accurate experimental work cannot be given.

Of the two subjects mentioned in the title, nutrition and manuring, the latter is an important aspect of the former and, in presenting this paper, it is proposed to deal only in a very general way with the broad subject of nutrition and to discuss in greater detail the manurial problems of the various fruits. This method of treatment appears to be the most profitable one at the present stage, since the experimental work on nutrition has largely referred to manuring, and it is thus on this subject that the most reliable guidance can be given to practice.

General Aspects of Nutrition.

From a general consideration of the plants concerned, it might well be thought that the main problems of nutrition would fall between those of the tree fruits and those of the ordinary farm and garden crops, and this thought seems to have been in the minds of several investigators in approaching the problems of soft fruits ; especially has it been thought that they would more nearly resemble those of farm crops. Facts which give rise to such ideas are that the soft fruits are perennials, which lay down fruit buds like the tree fruits, but at the same time are relatively small and shallow rooted, and likely to respond quickly to changing conditions of environment just as biennials or even annuals do. Experiments, however, have shown that analogies cannot be taken too far and that the various classes of soft fruits present their own particular problems.

Further examination of the fruits grouped together for discussion herein will show that differences are likely to obtain among them. Thus even Black and Red Currants have different fruiting habits ; Raspberries, Loganberries and Blackberries appear to form a group with quite dissimilar habits of growth from the others ; and Strawberries again present problems and habits of growth quite unlike any of the others.

There are two points which appear to require emphasis in considering nutritional problems of soft fruits, viz. : (i) in all growth is very rapid in the spring and early summer, and conditions must be

favourable for this, otherwise poor results will be obtained ; (ii) an adequate water supply in the soil during the fruiting period is fundamental to successful cultivation. The importance of this latter point has been clearly demonstrated for Strawberries in U.S.A.

Soil Requirements of Soft Fruits.

Bush fruits are grown on a wide variety of soils, both as regards texture, and lime status and acidity. Nevertheless, there are class preferences but these are often masked by the behaviour of varieties within the different classes. Moreover, as in tree fruits, success is attained by means of particular systems of manuring and various devices of management under conditions not naturally favourable.

The safest soils for bush fruits are undoubtedly well-drained, medium-textured loams, containing good supplies of humus and only small supplies of free carbonate of lime or even being slightly acid in reaction. Such soils ensure favourable conditions for root development : free movement of water, no waterlogging but an adequate moisture supply in early summer, and also a favourable reaction, ensuring a good supply of food-supplying bases yet no excess of lime, which substance is liable to promote lime-induced chlorosis. With regard to soil reaction, it seems that all classes of bush fruits are tolerant of a fair degree of acidity but many are susceptible to chlorosis on soils containing abundant supplies of carbonate of lime. Chlorosis has been noted on all classes of fruits considered in this paper but has usually only been serious in Raspberries, in which severe failures have been seen.

Gooseberries succeed on a wide range of soil textures but drainage must be good. Black Currants are noteworthy for tolerance of soil wetness and grow strongly on heavy soils of good fertility. Red Currants are also tolerant of a wide range of texture but are susceptible to potash starvation on poor, light soils. Raspberries are particularly affected by soil wetness and are liable to die out in alarming fashion on heavy soils during wet seasons, succeeding best on light soils and often throwing poor canes on heavy soils. Logans and Blackberries grow strongly on medium to fairly heavy soils, but again will not tolerate long periods of high soil moisture. Strawberries grow under a very wide range of soil conditions and varieties show wide preferences, the poor, hungry light soils being often favoured for early crops and the heavy soils for main crops where tonnage is of pre-eminent importance : certain varieties suffer severely on wet soils.

Manurial Requirements of Soft Fruits.

A. *Older Experiments on Soft Fruits.*

In this section, it is proposed to summarize the main results of early experimental field trials carried out on various soft fruits in England and in the U.S.A. In England, the two main series of experiments were carried out by Bedford and Pickering at Woburn, and by

DYER and SHRIVELL at Hadlow. The more important of the results obtained in experiments in the U.S.A. have been summarized by CHANDLER.

Experiments in England.

Woburn Experiments.—These experiments were carried out at two centres, viz., on a heavy soil at Ridgmont and on a poor sandy soil at Milbrook. An interesting feature of them is that the responses of various bush fruits to manures may be compared with the behaviour of tree fruits under similar manurial treatments.

In all the main manurial treatments given were dung at 12 and 30 tons to the acre annually or the equivalent of these dressings in the form of artificials.

At Ridgmont, on the heavy soil, no manurial treatment produced any significant effect on growth or cropping of any of the tree fruits used—Apples, Pears and Plums—the experiments on Apples covering a period of twenty-two years.

In contrast to these results with tree fruits, the effects on bush fruits are summarized as follows (Science and Fruit Growing, p. 89): "the reverse has proved to be the case with bush fruits, such as Currants, Gooseberries and Raspberries: those which were left unmanured have been practically exterminated, whilst those which were manured flourished. But the manure which was essential in these cases was a bulky organic manure, such as dung, since artificial manures produced but little more effect than no manure at all."

On the light soil at Milbrook, both top fruits—Apples, Pears, Plums and Cherries—and bush fruits responded to dung and artificials, and, at this centre, when potash was omitted from the complete artificials in an experiment with Apples, no response was obtained, possibly demonstrating that the main effects at this centre were due to potash.

At Ridgmont, farm crops, such as Potatos and Onions, and nursery Apple stocks responded similarly, and in the "normal" expected fashion, to manuring on the plots where previously bush and standard Apple trees had failed to show effects.

The main effects on the various bush fruits at Ridgmont may be summarized as follows:

Gooseberries.—Dung produced extraordinarily large effects, whereas only small responses resulted from artificials. In the latter case, the omission of either nitrogen, phosphorus or potassium from the mixture did not reduce the yields below those of the complete artificials.

Figures from the results are given in Table I.

In further experiments, the effect of adding a bulky inert material such as chaff with artificials was tested as a substitute for dung, but the chaff did not appear to affect the yields.

BEDFORD and PICKERING regard the huge effect of dung as the outstanding point of the results with Gooseberries.

Currants and Raspberries.—Experiments with these fruits were only

continued for five years, mainly owing to the incidence of diseases. The results were considered to be of the same order as for Gooseberries,

TABLE I.

Series.	Period.	Relative Yields.				
		No Manure.	Artificials.		Dung.	
			= 12 tons Dung.	= 30 tons Dung.	12 tons.	30 tons.
A	1900–07	100	70	113	446	644
B	1913–17	100	80	140	315	726
		Weights of Bushes.				
B	1913–17	100	92	124	210	696

Treatments.	No Manure.	Complete Artificials.	Omit Nitrogen.	Omit Phosphorus.	Omit Potassium.
Relative yields .	100	203	219	297	198

although the outstanding increases from dung were not obtained, but this was thought to be due probably to the short duration of the experiments.

Results for various crops were as follows :

TABLE II.

Crop.	Period.	Relative Yields.				
		No Manure.	Artificials.		Dung.	
			= 12 tons Dung.	= 12 tons Dung.	12 tons.	30 tons.
Black Currants .	1897–99	100	108	137	149	125
Red Currants* .	1897–1901	100	114	128	161	214
Raspberries .	1898–1901	100	126	102	130	195

* Results refer to both crops and weights of bushes.

In an experiment on Red Currants to show whether artificials could replace dung in part, a full dressing of dung alone gave higher yields than a light dressing of dung supplemented with artificials.

Strawberries.—The outstanding feature of numerous experiments carried out on Strawberries was considered to be the surprisingly small effects produced both from artificials and dung. Increases in yields from manuring averaged 12 per cent., dung showing superiority over artificials of 8 per cent.

Dung increased size and quality of the berries and longevity of the plants, and no manurial treatment produced any effect on date of ripening, although manures slightly prolonged the picking season.

The lack of results was considered to be due in part to the unfavourable character of the Ridgmont soil for Strawberries.

Hadlow Experiments.—At this centre, the general scheme of manuring aimed at comparing the effects of heavy dressings of dung and lighter dressings of this supplemented with artificial fertilizers containing nitrogen, phosphorus and potassium or only the first two. The two rates of dung were 25 tons and 12½ tons of London dung to the acre annually.

The soil at Hadlow is described as a clay loam overlying a deep bed of heavy clay, and was said to be a very poor soil.

At this centre, extensive series of experiments were also carried out on vegetables and on tree fruits, especially on Apples and Plums, and in all cases the importance of potash salts when artificials only were used was emphasized. This was especially striking with Apples.

There appears to have been great difficulty in these trials in keeping the various crops free from the effects of pests and diseases, and these circumstances led to much irregularity in the results in certain seasons.

The trials for which data are available relate to Gooseberries, Black and Red Currants, Raspberries and Strawberries.

Gooseberries.—These trials were fairly extensive and lasted over the period 1898–1908, twelve crops being harvested. The outstanding points in the results were as follows: the superiority of dung over complete artificials; the remarkable effects of potash salts in "artificials alone" treatment (where potash was not given the bushes yielding practically no crops in certain years), and also the action of potash even when dung was applied.

Figures taken from the results for twelve seasons illustrating these points are as follows:

TABLE III.

		Average Annual Yields per Acre. Lb.
Plot F.	25 tons London dung	5,000
,, B.	12½ tons London dung + complete artificials, less potash	3,300
	Do., but potash added	5,220
,, C.	No dung; nitrate and phosphate only	860
	No dung; nitrate, phosphate and potash	2,370

Black Currants.—Although three plantings were made it was only possible to take eight crops from these. The results were not so striking as in Gooseberries, but again established the importance of dung and potash salts, the latter possibly only when dung was not used.

The following are some of the main results over eight seasons :

TABLE IV.

		Average Annual Yields per Acre Lb.
Plot F.	25 tons London dung	1,645
,, B.	12½ tons London dung + complete artificials, less potash	1,326
	Do., but potash added	1,146
,, C.	No dung ; nitrate and phosphate only	737
	No dung ; nitrate, phosphate and potash	992

Red Currants.—Two plantings of Red Currants were established and eight crops were taken from these. The results were of the same order as those for Black Currants, with the exception that Red Currants gave better results in the absence of dung provided potash was given.

Results for eight crops are as follows :

TABLE V.

		Average Annual Yields per Acre. Lb.
Plot F.	25 tons London dung	1,310
,, B.	12½ tons London dung + complete artificials, less potash	870
	Do., but potash added	925
,, C.	No dung ; nitrate and phosphate only	655
	No dung ; nitrate, phosphate and potash	1,165

Raspberries.—Great difficulty was experienced with this crop and the results were variable. The main deductions were that heavy manuring was unnecessary and that when artificials were used potash was of great importance. The canes on the non-potash section of the " artificials " plot soon became stunted and obviously unhealthy.

Results for eight seasons are as follows :

TABLE VI.

		Average Annual Yields per Acre. Lb.
Plot F.	25 tons London dung	2,060
,, B.	12½ tons London dung + complete artificials, less potash	2,125
	Do., but potash added	2,000
,, C.	No dung ; nitrate and phosphate only	1,420
	No dung ; nitrate, phosphate and potash	1,970

Strawberries.—Trials were made on five plantations of Strawberries and lasted over nineteen years. The results were extremely variable, but nevertheless certain conclusions appeared justified. The main points appeared to be as follows : heavy dunging was not superior to light dunging together with artificials ; potash was unnecessary when dung was applied and indeed appeared harmful in earlier plantings, though not in later years ; potash in artificials alone was very effective. Artificials applied with light dung promoted earliness in one season only.

Results for the last four years of the trials were as under :

TABLE VII.

		Average Annual Yields per Acre. Lb.
Plot F.	25 tons London dung	4,270
,, B.	12½ tons London dung + nitrate and phosphate	3,200
,, C.	No dung ; nitrate and phosphate only	440
	No dung ; nitrate, phosphate and potash	1,430

Experiments in U.S.A.

Gooseberries and Red Currants.—A comprehensive experiment was carried out on these crops at Cornell University over the period 1913–22. The soil is a heavy clay on which the plants make very slow growth. The manurial treatments were very varied, including dung, artificials, tankage and dried blood.

No clear result emerged from the experiments on Red Currants, due perhaps to the incidence of " leaf spot " and to the apparent unsuitability of the soil for the crop.

In Gooseberries the main conclusions were as follows :

Dung produced the largest effects. Nitrogen used alone was effective, and an organic form such as dried blood appeared superior to an inorganic form. Potash was probably effective, the plants appearing healthier and holding their leaves later in the season than where potash was not used. Phosphorus produced no visible result nor any measurable effect on growth or yield.

In connexion with the lack of result from phosphorus, Maize plants were grown on a portion of the plots in 1920 and on the phosphorus-omitted plots the Maize plants failed to form ears, the response to phosphatic manures being 325 per cent., as measured by the total weight of the plants.

Marked benefits on Red Currants and slightly advantageous effects on Gooseberries were reported from liming an acid soil at Rhode Island.

Raspberries and Blackberries.—Experiments with these fruits appear very few, and the results are very variable and do not provide any very definite conclusions. Experiments at Cornell University seem to have been carried out on a soil rather unsuited to the crops, where dying out over winter and injury from certain fertilizer treatments were common. These experiments were on a soil similar to that used in the Gooseberry and Currant experiments described above.

With Raspberries, the main result was that nitrogen produced good effects on cane growth, but only small increases in cropping. No effects were produced by phosphorus or potassium in the absence of nitrogen.

Blackberries did not respond to any of the manurial treatments and proved to be very easily injured by dressings of nitrate of soda.

The general recommendation from older American experiments and experience is that it is of great importance to have the soil rich in humus prior to planting, and that after planting only little fertilizer will be required, nitrogen being given to Raspberries if growth falls off.

Strawberries.—The evidence relating to the effects of fertilizers on this crop is very conflicting and does not allow of any clear conclusions. The experiments clearly demonstrate the difficulties of carrying out investigations with this crop, the problems being particularly complicated owing to the U.S.A. practice of growing Strawberries in

matted rows. Under this system, problems of runner formation, vegetative growth, weed stimulation and injury from fertilizers on foliage are very complicated and confuse the simple issues.

The results of some of the more important experiments may be summarized as follows :

Bailey, working on sandy and gravelly soils in New York State, obtained beneficial effects from phosphorus and sometimes from potassium, but not from nitrogen, which was used in the form of nitrate. On these soils the working in of strawy materials reduced yields.

In Missouri, on a poor soil especially low in nitrogen, nitrogenous manures proved injurious, owing to weed stimulation, and acid phosphate was distinctly beneficial.

On the Cornell plots, previously discussed under Gooseberries, etc., Strawberries reacted like Maize to dressings of phosphorus, thus differing from all the other fruits.

Chandler, on sandy soils in New York State, did not obtain any clear effect from any fertilizer.

In Oregon, cover crops preparatory to planting were favourable and nitrogen was probably effective.

Evidence regarding liming is conflicting, one experiment showing injurious effects and another slight benefits.

B. *Recent Manurial Experiments.*

Experiments in England.

Pot Culture Experiments.—Before describing the various field experiments which have been carried out during recent years on various soft fruits, it will be useful to refer to the results obtained by the writer on these in sand culture experiments in pots. In these experiments, the effects of deficiencies of the essential elements, nitrogen, phosphorus, potassium, calcium and magnesium, and of total starvation treatment have been determined for Gooseberries, Black Currants, Raspberries and Strawberries. The plant characters studied were : times of opening of leaf and blossom buds, blossom characters, foliage characters, shoot growth, defoliation phenomena, crop weights and characters of fruits, and root systems. The effects of the reaction of the nutrient medium—*i.e.* alkalinity and acidity effects—were also studied in Strawberries.

The results have already been reported in detail and it is only proposed now to refer to one or two points which will be of interest in considering the field results. These points are as follows : deficiency of each element produces characteristic effects on the various plants ; the effects of a deficiency of any given element are similar for all the plants, though differing in detail ; the largest effects within a given time are produced by deficiencies of nitrogen and phosphorus, the plants resulting from such treatments suffering to an extent similar to totally starved plants.

It may be added that a knowledge of these deficiency effects has been found useful in diagnosing the nutritional status of various soft fruits in the field and in interpreting the effects of fertilizers in manurial experiments.

Field Experiments.

Gooseberries.—Many experiments have been carried out on the manuring of Gooseberries, especially in connexion with " leaf scorch," to which trouble this fruit is especially susceptible, and these have demonstrated the beneficial effects of sulphate of potash and of dung in such cases. As the result of these experiments and of the experience of fruit growers in all the main fruit areas, the importance of potash manures for Gooseberries is now firmly established. The following summaries of results are from experiments with which the writer has been identified and illustrate the main problems of the manuring of Gooseberries.

Long Ashton.—Two experiments have been initiated, one of which has been reported, the other still being in progress.

The first experiment was carried out on a fine sandy loam of medium to light texture, the variety of Gooseberry used being ' Keepsake,' with the bushes planted at 6 feet square.

The manurial treatments were as under : dung at 10 tons to the acre ; complete organic manure—consisting of dried blood, steamed bone flour, and sulphate of potash ; complete inorganic manure—nitrate of soda, superphosphate and sulphate of potash ; complete manure (part organic and part inorganic) less nitrogen, phosphorus and potassium respectively. All treatments except dung were calculated to supply nitrogen at 50 lb. an acre ; total phosphates at 120 lb. an acre ; and potash (K_2O) at 50 lb. an acre. All these dressings were applied annually in early March.

The main results were as follows :

Substantial increases in growth and cropping resulted from the treatments with dung and both complete manures ; increases probably resulted from nitrogen plus potash, and phosphates plus potash. The increases in growth were larger than those in cropping.

Nitrogen plus phosphates, but omitting potash, produced detrimental effects on growth and cropping where the bushes exhibited symptoms of potash deficiency.

Potash appeared to be the limiting factor to the growth of Gooseberry bushes on the area. Potash starvation was the cause of leaf scorch.

The field results were supported by chemical investigations which pointed clearly to potassium as the limiting factor.

A selection from the data to illustrate the various points is given in the table on p. 61.

In the second experiment, the bushes are planted between Apples, in the tree rows, the Apples being planted in December 1926 and the Gooseberries in December 1931. The manurial treatments, which

were commenced when the Apples were planted, are as follows: dung at 10 tons an acre; complete artificials; and complete artificials less nitrogen, phosphorus and potassium respectively. Nitrogen is

TABLE VIII.

Manurial Treatment.	Prunings for Two Seasons as per cent. of No Manure.	Leaf Scorch. Number of Bushes affected in 1926.	Cropping as per cent. No Manure 1922–26.
No manure . . .	100	25	100
Dung . . .	236	2	140
Complete organic .	159	1	151
Complete inorganic .	202	2	146
Complete mixed, organic and inorganic . .	193	4	132
Omit nitrogen . .	152	2	113
,, phosphate . .	148	1	90
,, potash . .	44	26	21

given as nitrate of soda at 2 cwt. an acre; phosphorus as superphosphate at 3 cwt. an acre; and potassium as sulphate of potash at 3 cwt. an acre; all dressings being applied annually in early March.

The soil on the plots over which the treatments are randomized shows two distinct types, both being of sandy loam texture but differing in that one type contains in the surface soil relatively low contents of organic matter and nitrogen and only a trace of carbonate of lime, and the other high contents of organic matter and nitrogen with over 4 per cent. of carbonate of lime.

Both the Apples (variety ' Lane's Prince Albert ') and Gooseberries (variety ' Keepsake ') have failed badly and remain stunted, showing marked symptoms of potassium deficiency, on the high humus area, whereas on the low humus area growth is much better, although the Gooseberries have throughout shown distinct symptoms of potassium deficiency and the Apples during the past two seasons have commenced to exhibit slight leaf scorch and restriction in shoot growth. It is impossible at the present time to distinguish visually between the effects of the other treatments, potash deficiency again proving the outstanding problem for both fruits.

It is of interest that Oats grown on the experimental area immediately prior to planting the Apples grew better on the high humus area than on the area of lower humus content. Tomatos and Buckwheat in pot cultures have also behaved like Oats.

Cannington, Somerset.—This experiment is of special interest because the plots contain, in addition to two varieties of Gooseberries, two varieties of dessert Apples and one variety each of Black Currants and Strawberries, and it is thus possible to compare the effects of various treatments on the different classes of fruits. The soil is a medium to heavy fine sandy, silty loam, mainly derived from Keuper Marl.

The plots were established in March 1929, when all fruits excepting the Strawberries were planted. The Gooseberry varieties are ' Keep-

sake,' a fairly weak growing sort, and ' Whitesmith ' which is much more robust.

The treatments given are: no manure; dung at 5 tons an acre; complete inorganic manure (nitrate of soda 2½ cwt., superphosphate 3 cwt., sulphate of potash 3 cwt.); complete inorganic less nitrogen, phosphorus and potassium respectively. With regard to the application of the manures, it should be said that an attempt was made to place the dung near the plants in the early seasons, the dressing being relatively light, and observations suggest that the method has been somewhat unsatisfactory and has resulted in rather sparse dressings to certain plants, especially the Strawberries, which consequently show signs of poor nutrition. This point will be evident in the notes below.

Results up to the end of 1933 have been reported by A. D. TURNER, who is in charge of the plots, and who has supplied the 1934 data for presentation here.

The following summarizes the main growth characters on the plots:

No manure: bushes are failures, especially ' Keepsake '; they exhibit severe leaf scorch.

Complete fertilizer: growths long and bushes robust. On ' Whitesmith ' the basal shoots require removal.

Dung: growth generally robust, but occasional plants show slight leaf scorch and only moderate vigour; much trouble with succulent young shoots coming from bases of branches which are broken by wind and by pickers—especially on ' Keepsake.' Bushes flower early in season but fruit is late in picking. Gooseberry mildew more severe than other plots.

Omit nitrogen: these bushes are the best of all treatments. Growth is vigorous and there is no breaking of shoots.

Omit phosphorus: growth is only moderate and some leaf scorch is present, probably due to previous low potash conditions.

Omit potassium: failures and as on " no manure " plot.

The total fruit yields for the seasons 1931–34 inclusive are as follows:

TABLE IX.

Treatment.	Yields per Bush (grms.) and Order of Yields.	
	' Keepsake.'	' Whitesmith.'
No manure . .	626 (5)	1,731 (6)*
Dung . . .	1,247 (3)	4,365 (2)
Complete fertilizer .	1,663 (2)	3,685 (3)
Omit nitrogen . .	1,825 (1)	5,623 (1)
,, phosphorus .	1,086 (4)	2,584 (4)
,, potassium . .	601 (6)	2,551 (5)

* All quantitative data relating to Cannington plots in this paper kindly supplied by Mr. A. D. TURNER.

The outstanding points of the results to date are as follows: the highest yields and the most satisfactory bushes are on the "omit nitrogen" plots; dung and complete fertilizer treatments appear to induce too many succulent growths, leading to breaking of shoots, and yields from them are comparable; potassium deficiency is the primary limiting factor to healthy growths; the poor results on the "omit phosphorus" plots may be due mostly to previous low potash conditions, as is suggested by the appearance of the bushes.

Perdiswell, Worcester.—At this centre, comparable manurial plots containing Gooseberries, Black Currants and Raspberries are situated in close proximity and allow of comparisons of the behaviour of the different plants to similar treatments under similar soil conditions. The soil at the centre is derived from a typical river gravel, consisting mainly of sand and containing many pebbles. It appears to be a free-rooting medium for trees and vegetables.

Gooseberry manurial plots were established in March 1925, two varieties, 'Whinham's Industry' and 'Keepsake,' planted at 6 feet square, being used. The manurial treatments were: sulphate of ammonia only; fish manure plus superphosphate; fish manure plus superphosphate plus sulphate of potash; dung. Dung was used at 10 tons an acre throughout, the other dressings being increased as the experiment progressed. Crops have been affected by frosts in two seasons and by sparrows in 1931.

The main points which have emerged have been discussed by GAUT and are as follows:

Sulphate of ammonia only led to stunting and leaf scorch, the condition of the bushes becoming progressively worse as the experiment was continued. The berries were very small and of poor quality.

On the "fish plus superphosphate" plots the bushes made good growth, with occasional signs of stunting and some leaf scorch.

On the "fish plus superphosphate plus potash" plot and on the "dung" plot, growth was over vigorous, the bushes meeting in the rows, and shoots were much too dense and luxuriant.

The crop weights from the four treatments were very similar and in all cases have been poor, due apparently to potash deficiency in two cases and to excess growth in the remaining two treatments, in addition to frost effects.

The total crops for the two varieties for four seasons, 1929–32 inclusive, are as under:

TABLE X.

Treatment.	Total Crops from $\frac{1}{5}$ acre. Lb.
1. Sulphate of ammonia	1,047
2. Fish manure, plus superphosphate	920
3. As 2, plus sulphate of potash	1,012
4. Dung	711

In discussing the results, GAUT states that the two lessons to be learned from the experiment are the great need of Gooseberries for potash manuring and the danger of over-stimulation with dung and nitrogenous manures.

Hartlip, Kent.—This experiment was carried out in a commercial fruit plantation containing standard Plums and Cherries, interplanted partly with Gooseberries and partly with Red Currants. During 1926, the year prior to the first experimental manurial treatment, Mangolds were interplanted between the bush fruits and made good growth. Raspberries were planted among a section of the Gooseberries in 1928 and showed severe symptoms of potash deficiency.

The soil is a fine sandy loam containing many stones, mainly flints.

When first visited in 1926, the Plums and Cherries were making fairly good growth (apart from die-back in the Cherries), but the Gooseberries and Red Currants were total failures, being stunted and showing severe leaf scorch.

Sulphate of potash was applied to areas containing Gooseberries and Red Currants, and comparable areas of the fruits left without this fertilizer. Dressings were applied in March 1927 and 1928, at a rate of 4 cwt. an acre on each occasion.

Following the experimental dressings, no visible effects on either Gooseberries or Currants could be observed in 1927, but in 1928 the Gooseberries showed a marked response, whereas the Red Currants were scarcely affected.

Chemical analyses on shoots of plants from the plots showed that the Gooseberries had utilized the potash manures, whereas the Red Currants had absorbed very little of the added fertilizer.

Relevant results are given in the following table:

TABLE XI.

Treatment.	Gooseberries.				Red Currants.		
	Per cent. increase in spread 1928 over 1927.	Leaf Scorch in 1928 as per cent. in 1927.	Potash (K_2O) in Ash.		Leaf Scorch in 1928 as per cent. in 1927.	Potash (K_2O) in Ash.	
			Leaves.	Stems.		Leaves.	Stems.
Sulphate of potash	42*	0·98	23·03	27·24	97·8	13·08	10·85
No manure .	13	90·5	4·45	6·69	107·8	6·42	7·82

The points requiring note in this experiment are the greater susceptibility to potash starvation of the Gooseberries and Red Currants than the Plums and Cherries, and the quicker utilization of the potash dressings by the Gooseberries than by the Red Currants.

Stoulton, Worcester.†—This centre provides data relative to the

* Red Currants not measured in 1928 as clearly no appreciable increase in growth.

† Experiments in conjunction with R. C. GAUT. Results unpublished.

action of potash and lime on a poor acid soil. The soil is derived from a river gravel deposit, the texture being a gravelly heavy sand. It is acid in reaction in the surface layers—lime requirement of the surface soil being 0·019 per cent.—but containing a trace of carbonate of lime in the subsoil, the reaction being practically neutral.

The plot was planted to Plums, interplanted with Gooseberries, variety 'Careless,' which requires generous treatment. In 1926, the young Plums were making only poor growth and the Gooseberries were in very poor condition, being stunted and severely scorched, and in certain areas showed complete dying out.

Two experiments were carried out, one on a better area and the other on a very poor area. In the former, the effects of dressings of sulphate of potash and of ground limestone were tested, and in the latter sulphate of potash only was tested in the initial stages of the experiment, a dressing of nitrate of soda being given later in 1931.

Both experiments were continued over the period 1927–31.

In the first experiment there were four plots, two receiving no manure, one sulphate of potash at 4 cwt. an acre each March, and one ground limestone at 2 tons an acre during the winter of 1926–27. In the second experiment, the treatments were: no manure and sulphate of potash at 4 cwt. an acre annually.

Data relating to spread of bushes, vigour of shoots and foliage, and severity of leaf scorch were obtained annually on both plots, and these showed conclusively that potash was the limiting factor to growth and that healthy, vigorous growth could be obtained even in the poorer bushes by means of the sulphate of potash dressings. Moreover, the effects of the potash dressings were visible at a considerable distance from the plots. No positive effect could be attributed to the lime dressing.

It was shown from the nitrate of soda treatment in 1931 that a further growth stimulus could be given to bushes already treated with sulphate of potash, but where the dressing was applied to bushes not previously treated with potash, no effect was obtained.

Data from the larger experiment—better area—are given in the following table:

TABLE XII.

Manurial Treatment.	Number of Bushes.	Spread. Per cent. increase 1927–30.	Vigour of Shoots. Per cent. increase 1927–30.	Leaf Scorch. Per cent. decrease 1927–30.
A. Sulphate of potash, 4 cwt. an acre. 1927–31 inclusive .	302	46	47	81
B. No manure . . .	280	36	16	14
C. Ground limestone, 2 tons an acre. Winter 1926–27 .	293	32	35	26
D. No manure	279	23	29	17

Chemical data obtained on the terminal shoots portions of the bushes in 1929 also showed clearly the need for potash and the reaction of the bushes to the dressings of sulphate of potash.

TABLE XIII.

Treatment.	Leaves.		Stems.	
	Total Ash in Dry Matter. Per cent.	Potash (K_2O) in Ash. Per cent.	Total Ash in Dry Matter. Per cent.	Potash (K_2O) in Ash. Per cent.
Sulphate of potash .	11·50	31·18	6·03	28·27
No manure . .	8·58	6·63	5·92	11·70

Black Currants.

Long Ashton.—A comprehensive experiment on the manuring of Black Currants was commenced in December 1927.

The soil is similar to that of the poor area referred to under Long Ashton Gooseberries, and in fact the two experimental plots adjoin. The bushes are of the variety ' Baldwin ' (Herefordshire strain) and are planted, 6 feet by 6 feet, as a solid block.

The manurial treatments are as follows: no manure, dung, complete artificials, complete artificials less nitrogen, phosphorus and potassium respectively. The manures are applied annually at the following rates per acre: dung at 10 tons; nitrogen as nitrate of soda at 4 cwt.; phosphorus as superphosphate at 3 cwt.; potassium as sulphate of potash at 3 cwt.

Since the experiment is not yet finished, the complete results cannot be presented, but data to the end of 1934, together with some qualitative observations, serve to show the salient points which are emerging from the trial.

Careful visual examinations of the growth characters on the plots have been made each season and these have shown that the outstanding problem is deficiency of potassium. Thus the " no manure " and " omit potassium " plots stand out for poor, patchy growth, each season towards July the leaves appearing pale and developing marginal leaf scorch. Observations made on September 26, 1933, illustrate the growth conditions.

Dung, growth very vigorous; complete artificials, good to vigorous; omit nitrogen, good and no clear symptoms of nitrogen shortage; omit phosphorus, good to fairly good, no distinctive symptoms of shortage of phosphorus; omit potassium, growth medium to poor, all bushes show medium to slight marginal leaf scorch; no manure, as omit potassium.

Each season the bushes on all plots have been attacked by the leaf spot fungus *Pseudopeziza Ribis*, which has caused premature defoliation in spite of July spraying with Bordeaux mixture. A feature

of the attack is that generally it has been much *less* severe on the "no manure" and "omit potassium" bushes, and in some seasons these bushes have held their foliage later than those on the other plots for this reason.

The quantitative data so far analysed relate to pruning wood removed for the seasons 1927–34 inclusive, and crop weights for the seasons 1929–34 inclusive. The crops weights have varied from light to medium and there has, so far, been no really heavy crop.

TABLE XIV.

Pruning Data—Mean Weights in grms. per Bush, per Season, for each Treatment.

	Grms.
No manure	658
Dung	858
Complete artificials	724
Omit nitrogen	674
,, phosphorus	656
,, potassium	646

The weights can only be regarded as a very rough index of growth, and although they indicate the greater vigour on the dung and complete artificials plot, actually an analysis by the variance method shows that none of the differences are significant.

TABLE XV.

Cropping Data—Mean Weights in grms. per Bush, per Season, for each Treatment.

	Grms.
No manure	731
Dung	1,154
Complete artificials	1,093
Omit nitrogen	974
,, phosphorus	947
,, potassium	694

The order of cropping shown above agrees with the order of vigour as noted in the field, dung and complete artificials showing the highest group, omit nitrogen and phosphorus respectively the next, and no manure and omit potassium the lowest. Again using the method of variance, it is found that the means of any two treatments must differ by 368·1 to be significantly different, and applying this it is found that:

(*a*) dung has given a significantly higher yield than omit potassium or no manure.

(*b*) the yield from complete artificials is also significantly higher than that from omit potassium.

The crop yields thus reflect the fact that deficiency of potassium is the outstanding problem.

Cannington, Somerset.—The layout and treatments given to this plot have been described under the Gooseberry section. The results on the Black Currants to 1933 have also been described by A. D. TURNER.

The main points regarding growth features are as follows :

No manure : growth is fairly good, foliage is slightly pale during the early summer, and leaf scorch becomes medium with a few bushes severe in the autumn.

Complete artificials : growth is vigorous and excellent in all respects, and the foliage does not show scorching in the autumn.

Dung : growth is very vigorous and the bushes are of spreading habit. Slight scorch is developed late in the season, probably due to uneven spreading of the manure.

Omit nitrogen : growth is good but vigour is slightly behind that of complete artificials and leaves are slightly on pale side. No scorch is developed in the autumn.

Omit phosphorus : growth is good and vigour almost as complete artificials. Occasional bushes show slight scorching late in the season.

Omit potassium : growth characters are as on " no manure " plot but scorching is rather more severe.

The crops on the plots have been good, the total yields for the seasons 1931 to 1934 inclusive being as follows :

TABLE XVI.

Treatments.	Yields per Bush (grms.) and Order of Yields.
No manure . . .	6,169 (4)
Dung	7,584 (1)
Complete fertilizer . .	6,478 (3)
Omit nitrogen . . .	5,702 (5)
,, phosphorus . . .	6,877 (2)
,, potassium . . .	5,363 (6)

Comparison with the results for Gooseberries in this experiment shows several points of interest. Black Currants behave more satisfactorily to the generous treatments, dung and complete artificials ; Gooseberries appear more sensitive to the various manurial treatments than Black Currants ; deficiency of potassium is much more serious for Gooseberries than for Black Currants ; " omit nitrogen " treatment, which is so excellent for Gooseberries, gives relatively poor results for Black Currants ; phosphorus omission appears unimportant.

Perdiswell, Worcester.—The experiment with Black Currants was conducted simultaneously with that on the Gooseberries, the soil conditions being similar. Four varieties, representative of the four groups of Black Currants, were used, viz. ' French,' ' Goliath,' ' Boskoop,' and ' Baldwin.' The manurial scheme was identical with that for Gooseberries.

The results obtained have been reported by GAUT, the main points requiring note being as follows :

Growth throughout the experiment was vigorous on all plots, but under the " sulphate of ammonia " and " fish manure plus superphosphate " plots there was evidence of deficiency of potassium, usually showing in definite patches. Differences were much less than in the Gooseberry experiment where potassium deficiency was much more serious. Cropping was greatly interfered with by spring frosts, and of the seasons in which crops were taken, 1927–32, frosts and cold spring conditions are stated to have reduced crops seriously in every season excepting 1930 and 1932. In 1932, however, " reversion " disease appeared suddenly and seriously, and prevented the obtaining of critical data in that season. Hence only in 1930 could the crops be regarded as developing under favourable conditions.

The mean results for each treatment, totals for period 1929–31 inclusive and for 1930, for one-fifteenth of an acre, are given below :

TABLE XVII.

Treatments.	Mean Totals, 1929–31. Lb.	Means 1930. Lb.
Sulphate of Ammonia . .	1,204	490
Fish manure plus superphosphate.	1,197	480
Fish manure plus superphosphate plus sulphate of potash . .	1,349	543
Dung	1,355	588

The results at this centre again suggest the need for potassic manures for Black Currants and also show that Black Currants are less affected by extreme manurial conditions than are Gooseberries.

Red Currants.

Red Currants have not been the subject of critical manurial experiments in this country of recent years, the experiment at Hartlip, previously described, being the only one known to the writer. Many observations made on Red Currant plantations, however, have shown the pre-eminent need for potassic manuring of this fruit. Moreover, the observation made at Hartlip relative to the slow reaction of Red Currants to potash manuring when the bushes are strongly deficient in potassium has been confirmed in several commercial plantations. (See also the section following *re* experiments in Europe.)

Raspberries.

Experiments on the manuring of Raspberries have been few, possibly owing to the difficulties during recent years of obtaining clean stocks, true to name, suitable for critical investigations.

Two sets of trials have been carried out at East Malling and one at Perdiswell, whilst a trial is in progress at Long Ashton on the plots previously used for the Gooseberry manurial experiment described earlier in the paper.

East Malling.—In the first experiment, four varieties, ' Pyne's Royal,' ' Baumforth's Seedling B,' ' Devon ' and ' Bath's Perfection,' were compared on manured and unmanured plots. The manured land received moderate dressings of dung and shoddy in alternate years and in addition spring dressings of fish or meat meal. The unmanured land received no addition of manures from 1918, when the experiment was started, but green crops were ploughed in in 1921 and 1922.

The effect on cane growth is illustrated by the facts that, in 1922, ' Baumforth B ' produced 20 per cent. more canes on the manured land, although the canes were slightly taller on the unmanured area, whilst with ' Pyne's Royal ' there was almost 300 per cent. more canes on the manured land, where the canes were also taller.

The crops in 1923 gave the following results :

' Baumforth B,' 20 per cent. higher yield on the unmanured land ; ' Bath's Perfection,' yields practically identical on both plots, the yields being very poor on both ; ' Pyne's Royal,' 170 per cent. increase on the manured area. The result with ' Baumforth B ' was complicated by the incidence of mosaic disease, which appeared more severe on the manured land.

The second experiment was on a large scale and thoroughly comprehensive, the treatments being arranged in the form of randomized blocks. Two varieties were used, ' Pyne's Royal,' a weakly growing variety which throws new cane very sparsely and which had given disappointing results at East Malling, and ' Lloyd George,' which is characterized by vigour of cane growth. In planning the experiment, it was thought that the most important object in manuring ' Pyne's Royal ' would be to stimulate cane production, whilst with ' Lloyd George ' the problem appeared to be one of increasing fruitfulness without over-stimulation of cane growth. Thus, for the former variety, emphasis was placed on the use of nitrogenous dressings and for the latter on problems of potash manuring.

The manurial treatments for the two varieties were as under :

(*a*) ' Pyne's Royal.'

1. 1½ cwt. sulphate of ammonia.
2. 3 ,, ,, ,, ,,
3. 1½ ,, ,, ,, ,, + 3 cwt. sulphate of potash.
4. 3 ,, ,, ,, ,, + ,, ,, ,, ,,
5. 10 ,, shoddy + 1½ cwt. sulphate of ammonia.
6. 10 ,, ,, + 3 ,, ,, ,, ,,
7. 10 ,, ,, + 1½ ,, ,, ,, ,, + 3 cwt. sulphate of potash.
8. 10 ,, ,, + 3 ,, ,, ,, ,, + ditto.
9. 20 ,, ,, + 1½ ,, ,, ,, ,,
10. 20 ,, ,, + 3 ,, ,, ,, ,,
11. 20 ,, ,, + 1½ ,, ,, ,, ,, + 3 cwt. sulphate of potash.
12. 20 ,, ,, + 3 ,, ,, ,, ,, + ditto.

(*b*) 'LLOYD GEORGE.'

1. Nil.
2. 11½ cwt. kainit, applied in December.
3. 11½ ,, ,, ,, ,, March.
4. 3 ,, sulphate of potash, applied in December.
5. 3 ,, ,, ,, ,, ,, March.
6. 1½ ,, ,, ,, ammonia.
7. 1½ ,, ,, ,, ,, + 11½ cwt. kainit, applied in December.
8. 1½ ,, ,, ,, ,, + 11½ ,, ,, ,, ,, March.
9. 1½ ,, ,, ,, ,, + 3 cwt. sulphate of potash, applied in December.
10. 1½ ,, ,, ,, ,, + 3 cwt. sulphate of potash, applied in December.

The soil on which the experiment was carried out is described as a loam of variable depth derived from river terrace material overlying the Hythe beds.

The main results were as follows :

'Pyne's Royal.'

(1) Shoddy increased cane growth but not cropping; extra nitrogen in the form of sulphate of ammonia was detrimental to both cane growth and cropping.

(2) Sulphate of ammonia was to some extent beneficial where shoddy was not given.

(3) Sulphate of potash was beneficial both to cropping and directly or indirectly to cane growth, though the action was slow and the increases small—largest differences in crop was, in 1931, 4 cwt. per acre.

Note.—The yields with this variety were always poor, the heaviest crop being less than 1 ton an acre.

'Lloyd George.'

(1) Sulphate of ammonia alone increased cane growth in the early part of the trial but never increased the crop.

(2) Kainit either alone or with sulphate of ammonia did not increase cane growth.

(3) Sulphate of potash was always beneficial to cane growth and to cropping. Sulphate of ammonia with it in some seasons produced extra effects.

(4) Kainit was less effective than sulphate of potash and appeared to have harmful effects in some seasons.

(5) December applications of kainit appeared superior to March dressings in dry seasons and *vice versa* in wet ones. Results for sulphate of potash in this connexion were the reverse of those for kainit.

(6) Leaf scorch was prevalent on the plots receiving no manure and sulphate of ammonia only.

The general conclusion from the experiment is " the necessity for a proper balance between nitrogen and potash, the more vital necessity on this soil appearing to be potash."

" Nitrogen may, up to a point, produce more cane by itself but has never increased the crop except in the presence of potash. Indeed, alone it has been depressing in both cases."

Perdiswell, Worcs.—A manurial trial, using the varieties ' Lloyd George ' and ' Pyne's Royal,' was planned along the lines described for the Gooseberry and Black Currant experiments at this centre, and was commenced simultaneously with those tests in spring 1925. Shortly after the beginning of the experiment, the variety ' Lloyd George ' became obviously severely affected with mosaic, which subsequently completely overshadowed any manurial effects. ' Pyne's Royal,' however, grew well and visual observations on this variety were made by Mr. GAUT and the writer each season in July until 1932.

No obvious differences due to the manurial treatments could be observed up to 1930 but, in 1931, potash deficiency effects were clearly evident on the plots receiving no potash, *i.e.* receiving sulphate of ammonia only, and fish meal plus superphosphate. On the plots receiving fish meal and superphosphate plus sulphate of potash and dung respectively growth was excellent and the crops heavy.

Observations in July 1932 showed a similar state of affairs, and there can be no doubt of the beneficial action of sulphate of potash in this experiment.

Strawberries.

During the past decade, it has been almost impossible to carry out satisfactory manurial trials on Strawberries in most Strawberry-growing districts because of the numerous devastating diseases which have been prevalent.

Comprehensive experiments have been attempted at Long Ashton, and Botley, Hants, and smaller series at Cannington.

At the first two centres, pathological troubles have seriously interfered with the trials, and at Botley it is not yet possible to formulate definite conclusions regarding the influence of manures in the tests. At Long Ashton and Cannington, however, certain results have been obtained which are worthy of record.

Long Ashton.—Two experiments are in progress at this centre and both take the form of long period investigations in which Strawberries are grown continuously, in three-year periods, under definite manurial treatments.

The plots in the two experiments adjoin each other, the soil being similar in both, a fine sandy loam derived from sandstone and marl beds in the Keuper series, and being of moderate fertility and naturally slightly acid. A dressing of ground limestone at 2 tons an acre was applied in 1923 to counteract the acidity prior to commencing the experiments.

The first experiment was started in the spring of 1924, and the second in the autumn of the following year, and the plots have both been under Strawberries, variety ' Royal Sovereign,' continuously since then. The manurial treatments in the first experiment are as follows :

A. *Dung* at 20 tons an acre to be ploughed in previous to planting. No further manuring to be given during three-year period.

B. *Dung* at 10 tons an acre to be ploughed in as in A. *In addition* a complete fertilizer to be given each spring as under :

Sulphate of ammonia	to supply 20 lb. nitrogen an acre.
Superphosphate	150 lb. total phosphate an acre.
Sulphate of potash	50 lb. K_2O an acre.

C. *Shoddy* (on basis of 5 per cent. total nitrogen) at rate of 2 tons an acre to be ploughed in as in A. *In addition* to be given each spring as under :

Steamed bone flour	150 lb. total phosphate an acre.
Sulphate of potash	50 lb. K_2O an acre.

D. *A "Complete Organic" manure* (non-bulky) to be applied each spring as under :

Dried blood	40 lb. nitrogen an acre.
Steamed bone flour	150 lb. total phosphate an acre.
Sulphate of potash	50 lb. K_2O an acre.

E. *A "Complete Inorganic" manure* to be applied each spring as under :

Sulphate of ammonia	40 lb. nitrogen an acre.
Superphosphate	150 lb. total phosphate an acre.
Sulphate of potash	50 lb. K_2O an acre.

F. *"Organic Manure"* containing nitrogen and phosphate but no potash to be given (*cf.* D.) each spring.

Dried blood	40 lb. nitrogen an acre.
Steamed bone flour	150 lb. total phosphate an acre.

H. *Control Plot.*—No manure to be given throughout the period of the experiment.

The treatments in the second experiment are intended primarily to study the effects of deficiencies of nitrogen, phosphorus and potassium.

The details of the treatment are as follows :

Dung at 20 tons an acre previous to planting every three years.
Complete artificials each spring.
,, ,, less nitrogen each spring.
,, ,, ,, phosphorus each spring.
,, ,, ,, potassium each spring.

In all artificials dressings nitrogen is given as nitrate of soda to supply 40 lb. nitrogen ; phosphorus as superphosphate to supply 100 lb. total phosphate ; potassium as sulphate of potash to supply 100 lb. K_2O.

In both experiments the treatments are in triplicate and arranged in randomized blocks.

The quantitative results in both experiments have been seriously affected by diseases such as Red Plant, Aphis Plant, Tarsonemid Mite, and Cockchafer Grub, so that in most seasons the quantitative data do not give a clear picture of the results. In the second experiment, the results have never been satisfactory, but in the third planting in the first experiment the plants remained practically free from troubles and were of excellent appearance. For this reason, a special study was made of the plots in 1931, the second and main cropping year of the planting. Data relating to vigour, yields and chemical characters of the fruits in that season have been previously reported, and are summarized in Table XVIII.

The above data reflect the general character of the results which have been obtained in other seasons also, the main points of which have been as follows : the superiority of the dunged plots ; good results

on the shoddy plots ; intermediate results on the sulphate of ammonia and dried blood plots, the former being definitely better ; poor results

TABLE XVIII.

Vigour and Yields, 1931.

	Vigour Markings and Plot Order.	Crop Yields (kilos.) and Plot Order.
A. Dung at planting	33 (2)	253·96 (2)
B. Dung + artificials	34 (1)	277·21 (1)
C. Shoddy + phosphates + potash .	31 (3)	244·36 (3)
D. Dried blood + phosphates + potash .	28½ (5)	223·80 (5)
E. Sulphate of ammonia + phosphates + potash	31 (3)	238·04 (4)
F. Dried blood + phosphates . .	23 (6)	199·13 (6)
H. No manure	22½ (7)	181·96 (7)

on the plots not receiving potash and those receiving no manure, and the similarity in performance from these treatments.

Quality : Points of chemical quality are indicated by the following orders of the plots for the various points considered. (Descending orders.)

	High.						Low.
Size of berries . .	E	B	A	C	F	D	H
Total nitrogen content .	B	F	E	D	A	H	C
Total acids content .	C	D	A	B	H	E	F
Total sugars content .	H	C	A	B	E	F	D
Reducing sugars content	H	E	C	F	A	D	B
Sucrose content . .	C	B	A	H	D	E	F
Total ash content .	B	E	C	D	A	H	F
Total potash content .	E	B	A	C	D	H	F

The points of importance which emerge from the above orders are as follows :

The largest berries are produced by complete inorganic fertilizer and by dung treatments ; nitrogen is highest where inorganic nitrogen is applied or where potash is deficient ; potassium deficient berries are subacid ; total sugars are highest in " no manure " and " shoddy " plots, and low in " potash deficient " berries ; reducing sugars are especially high in the " no manure " berries ; sucrose (cane sugar) is especially low in " potash deficient " berries ; total ash and potash are high on plots receiving inorganic manures and low on those receiving no manure or no potash.

It is thus established on these plots that quality of the produce is definitely affected in well-defined ways, as well as vigour and yields. In this connexion it should be mentioned that the following features relating to flavour have been noted in the berries from the various plots, viz. dung and complete artificials (A, B, and E), flavour rather thin and watery ; shoddy (C), excellent, full flavour ; omit potash and no manure (F, H), sweet, flavour good.

In the second experiment, where the various deficiency treatments are given, it has been possible so far to recognize qualitatively deficiency effects from omit phosphorus and potassium respectively. Without phosphorus the plants have been almost total failures, the foliage has exhibited high purple and bronze tints and the fruit has been small, rather acid and markedly lacking in sweetness. Potash deficiency has been shown by marginal scorching of the foliage and berry quality as in the first experiment.

The deficiency effects from phosphorus are of great interest since this is the first indication of this deficiency shown in the field in this country by any fruit plant and agrees with observations previously mentioned under experiments in U.S.A.

Cannington, Somerset.—The plants concerned in this experiment are planted in rows between the Gooseberry and Black Currant bushes on the plots already described. The Apples and bush fruits were planted in March 1929, when the manurial treatments were also begun. The Strawberries, variety 'Royal Sovereign,' of which there were three strains, were planted in August 1930, eighteen months after the other fruits. The plants were cropped as maidens in 1930, when three runners per plant were also taken. Three further crops were taken in 1931–34 inclusive, after which the experiment was concluded. The full results have been reported recently by A. D. Turner.

Data are available for vigour, longevity of the plants, crop weights and chemical features of the fruits of the 1933 crop (dung plot excepted). In considering the results, it should be noted that some of the plants on the "dung" and "omit phosphorus" plots appear to have suffered from potash deficiency, since weak patches on these plots show symptoms of this trouble.

Vigour: notes made in June 1933 and 1934 serve to show the salient features relating to vigour.

1933.

Omit potassium.—Severe stunting and leaf scorch.
Omit phosphorus.—Growth generally good but slightly uneven, with weak plants showing scorch.
No manure.—As omit potassium.
Dung.—Growth fairly good but rather uneven, and weak plants show scorch.
Omit nitrogen.—Growth good. No adverse effects.
Complete artificials.—Growth excellent.

1934.

Omit potassium.—Growth very poor and plants dwarfed, scorch severe; practically no crop.
Omit phosphorus.—Growth generally good but some weak scorch patches.
No manure.—Severe stunting and scorch effects; one row fairly good.
Dung.—Growth poor with strong scorching effects.
Omit nitrogen.—Good growth, but slightly paler foliage than complete artificials.
Complete artificials.—Excellent vigour and appearance.

The order of vigour in 1934 would thus appear to have been: complete artificials; omit nitrogen; omit phosphorus; dung; no manure; omit potassium.

In the autumn of 1934 counts were made of the plants remaining on the plots, these being arranged into three grades, roughly strong, medium, and weak. The figures for grade I, strong plants, given below show that they support the vigour observations above.

TABLE XIX.

Treatments.	Numbers of Grade I Plants (Autumn 1934).		
	Strain A.	Strain B.	Strain C.
Complete artificials . .	256	52	28
Omit nitrogen . . .	186	42	31
Omit phosphorus . .	113	24	11
Dung	53	9	6
No manure . . .	39	0	2
Omit potassium . .	3	6	5

Cropping: the total mean crops per row for the period 1931–34 for each treatment are given in the following table.

TABLE XX.

	Total Mean Weights per Row, Seasons 1931–34 (kilos.), and Orders of Yields.		
	Strain A.	Strain B.	Strain C.
Complete artificials . .	23·41 (1)	20·44 (1)	24·48 (1)
Omit nitrogen . . .	15·46 (2)	19·69 (2)	19·95 (2)
No manure . . .	9·63 (3)	12·14 (4)	12·85 (4)
Dung	6·21 (5)	15·73 (3)	18·58 (3)
Omit phosphorus . .	8·40 (4)	8·55 (5)	12·16 (5)
Omit potassium . .	3·42 (6)	7·60 (6)	9·96 (6)

The orders of cropping are substantially those of vigour with the exception of the "no manure" and "omit phosphorus" treatments. The latter is of interest in that vigorous plants are associated with poor cropping.

As regards cropping, the order for the Strawberries differs somewhat from that of both Black Currants and Gooseberries.

All three fruits agree in giving the poorest results from the omit potassium, but whereas Black Currants gave poor results when nitrogen was omitted, Gooseberries and Strawberries gave good ones. Dung was more effective for Black Currants than for the other two fruits, and complete artificials was the best treatment for Strawberries.

Composition of fruits: as previously stated; fruits from the dunged plots were not examined.

The main points of the results are as follows:

Berry size: omit potassium, very small; omit phosphorus and no manure, also small.

Total nitrogen: no manure and omit potassium, high (possibly a reflection of low potash conditions); omit nitrogen, low (reflecting treatment).

Acidity : low in omit potassium and no manure (reflecting low potash).
Total ash : low, omit potassium and no manure (reflecting low potash) ; high complete artificials (reflecting this treatment).
Potash : low, no manure and omit potassium (reflecting low potash) ; also on low side for phosphorus (reflecting rather low potassium also) ; high, complete artificials ; and fairly high omit nitrogen.
Phosphorus : omit phosphorus not reflected, probably masked by low potash conditions which raise phosphorus content. High, omit potassium value.

The results of the chemical analysis thus show many features which would be expected from the field results, and again demonstrate how quality is substantially affected by manurial treatment.

Experiments in Europe.

Experiments carried out in Europe emphasize without exception the great importance of potash manuring for the soft fruits, Gooseberries, Red Currants, Black Currants and Strawberries, and also refer to the injurious effects of chlorine in such fertilizers as potash salts, sulphate of potash being regarded as the desirable fertilizer to supply the requirements for potash.

The experiments refer to Germany, Holland, Austria and Denmark.

The main conclusions are as follows :

Gooseberries.—The primary manurial requirement is potash. Sulphate of potash is preferred, but high yields have been obtained by chloride of potash (LIERKE's experiments). The ratio of nitrogen/potassium is of importance.

Red Currants.—(1) The requirements for potash are similar to those of the Gooseberry. According to REMY, the Red Currant is less susceptible to potash deficiency than the Potato, but SCHOEVERS instances a case where Red Currants showed drastic leaf scorch on land previously used for Potatos and regularly dunged. Scorch was cured by a heavy dressing of sulphate of potash in this case.

(2) This fruit is very susceptible to chloride injury which, in general appearance, is similar to potash deficiency, but the symptoms differ in detail and the effects are usually less drastic.

(3) Potash deficiency has been induced by the use of nitrate of soda on otherwise unmanured plots.

(4) Potash deficiency results in the following characters of the fruits : lowered yields, small size of berries, small percentage of juice to husk and kernel, low percentage acidity and sugar, and poor flavour.

Black Currants.—This fruit is much more resistant to potash deficiency and to chlorine injury than Gooseberries or Red Currants.

Strawberries.—In experiments of LIERKE, potassium, especially as chloride, gave the highest yields, phosphorus next and nitrogen was least effective.

Experiments in U.S.A.

During recent years fertilizer experiments on soft fruits do not appear to have claimed much attention, with the possible exception of the Strawberry. This is probably because of the greater importance

of the tree fruits, of which nutritional problems have been very intensively investigated.

Raspberries.—Experimental results are available on Black and Red Raspberries. For these fruits it appears that the general consensus of opinion is that the ground should be well supplied with organic matter previous to planting, after which the main requirements will be for moderate dressings of nitrogen. Many of the experimenters take this view as the starting point in their work.

Typical experiments along these lines are described by CHERRY on Black Raspberries, and by CHILDS and HOFFMAN on Red Raspberries.

In the former case, the land was liberally dressed with dung prior to planting, and then a test of annual dressings of sulphate of ammonia, superphosphate and sulphate of potash made.

The results showed that nitrogen, phosphorus and potassium all increased yields, potassium least of the three.

Nitrogen seemed most effective and also increased cane growth.

Sulphate of potash increased the sugars content of the plants.

CHILDS and HOFFMAN worked on plots into which soy-beans had been ploughed in 1926 prior to planting in 1929. Superphosphate at 300 lb. an acre was given as a basal dressing.

Under these conditions, dressings of nitrate of soda applied in spring and autumn at 50 lb., 200 lb. and 300 lb. rates were tested.

The highest dressing was found to produce significant yields over two seasons, but the increases for 200 lb. were not significantly greater than the 50 lb. dressing.

STENE in Rhode Island has shown that on two series of plots, a silt loam and a poor stony loam, potassium is more effective for Red Raspberries than either nitrogen or phosphorus, the results being regarded as counter to general opinion. His results are as follows:

TABLE XXI.

	Relative Yields.	
	Silt Loam.	Stony Loam.
Complete artificials . .	100	100
No manure . . .	—	37
Omit potassium . .	47	53
,, nitrogen . . .	70	69
,, phosphorus . .	82	84

The results of STENE would thus seem to fall into line more closely with English results than those of other U.S. workers.

Strawberries.—It is difficult to apply results on Strawberries in the U.S.A. to this country, since the conditions in the former country are very varied and the crop is grown under widely differing methods in different sections. Thus the crop may be grown as an annual, as in

Louisiana, or on the matted row or hill systems. Much interest is taken in the question of travelling quality of the fruit and thus of the effects of fertilizers on firmness.

As for Raspberries, most interest has been centred around the use of nitrogenous fertilizers.

The following illustrate some of the more important points :

Hoagland and Snyder have examined the effects of the so-called minor elements and have shown that boron is essential to the growth of the Strawberry. They consider that this point may be of importance in connexion with greenhouse plants and with certain diseases. Healthy plants were obtained when 0·1 part per million boron was used in the nutrient solution.

Strawberries were also found to be damaged by fairly low concentrations of sodium chloride and sodium sulphate, the plants being shown to accumulate much chlorine in the leaves under these conditions.

An alkaline reaction due to sodium bicarbonate was also harmful and plants seemed easily damaged by alkaline conditions produced in this way.

J. H. Clark has also shown that in a strongly acid medium, pH 4·6, nitrate of soda was superior to sulphate of ammonia for Strawberries but the reverse was the case at pH 6·4, which is only slightly acid.

Darrow, and Darrow and Waldo have carried out comprehensive field tests with fertilizers in which yields, firmness, flavour, etc., have been determined.

Darrow found that firmness was only affected by nitrogen through this element increasing the size of the berries.

As regards flavour, muriate and sulphate of potash promoted sourness and the berries lacked flavour ; with nitrogen and potassium the berries were less sour than with potassium alone ; superphosphate gave a sweet berry, and nitrogen plus phosphorus gave the sweetest and fullest flavour ; " no manure " and " nitrogen only " berries were more sour than those from phosphorus only.

In preserves made from the fruit, berries from the treatments nitrogen, nitrogen plus phosphorus, and phosphorus were superior to those from potassium and potassium plus phosphorus.

The higher acidity from potassium and the sweetness from phosphorus are in agreement with English results, where potassium deficiency is associated with sub-acid berries and phosphorus deficiency with high acidity and low sugars.

Darrow and Waldo obtained large increases from nitrogen, phosphorus and potassium, used alone or in combinations, but organic nitrogen appeared superior to inorganic, damage occurring from high dressings of the latter, and higher yields resulted from nitrogen alone than from combinations of nitrogen with the other two elements. It is suggested that small amounts only of phosphorus and potassium are required.

Berry size and plant vigour were increased by fertilizers ; the

increased vigour resulted in decay of the berries on the plant under wet conditions ; berries were later where no nitrogen was applied. Damage was greatest where inorganic nitrogen was used under conditions of drying winds, and potash appeared to be advantageous in such cases.

Wentworth in New Hampshire concluded that nitrate of soda, although increasing foliage amount, more frequently reduced than increased yields.

Taylor in Alabama found that winter applications of nitrogen increased plant size, numbers of blossoms and berries, percentage of high-grade fruits and size of berries. It appeared advantageous to apply extra nitrogen just prior to cropping in additon to the winter dressings. Superphosphate also produced beneficial effects, but not potash manures.

Greve and Shoemaker showed that early spring applications of nitrate of soda only decreased firmness to a very small extent ; nitrogen content and acidity were increased and sugars decreased.

Kimbrough in examining the effects of nitrogen and potassium in spring dressings on fruit quality found only slight adverse effects from heavy dressings of nitrate and no beneficial effects from potassium.

He also showed that quality was more affected by rainfall and soil moisture content than by different fertilizer treatments.

Overholser and Claypool found that nitrogen and phosphorus both decreased firmness.

Discussion of Results of Manurial Experiments.

From the experiments described in the previous section, it is possible to obtain considerable guidance in manurial programmes for the various classes of soft fruits. The only fruits for which experimental data from this country are completely lacking are Blackberries and Loganberries, but from observations made in commercial plantations of these fruits it would appear that the problems will, in many ways, resemble those of Raspberries. Potash deficiency is possibly the major point requiring attention ; excess of inorganic nitrogenous dressings should be avoided ; whilst moderate dressings of dung and shoddy will be beneficial where soils are poor or lack organic matter.

The following are the major points which arise from the experimental data on the other fruits.

Gooseberries.—Bedford and Pickering concluded that heavy dressings of dung provided the key to the problems of manuring this fruit, being greatly superior to artificial fertilizers, and it has also been shown at Hadlow, Long Ashton and Cannington in this country, and by Chandler in U.S.A., that dung is of great importance. The experiments at Cannington and Perdiswell, especially the latter, however, show that dung may stimulate growth too much and bring about undesirable effects.

In all experiments with Gooseberries, the great need for potassium has been demonstrated and there is no doubt that this element is of

first importance. DYER and SHRIVELL even found it of benefit when dung was given. The Cannington experiment shows that nitrogen must be used with caution on some soils.

Experiments at Woburn, Long Ashton and Hartlip have shown that Gooseberries are more susceptible than tree fruits to manurial treatment, in all cases potassium being the limiting factor. One experiment at Long Ashton also shows that Gooseberries (and Apples) react differently to soil conditions from Oats, Tomatos and Buckwheat, being apparently poorer potash feeders than these annuals.

Phosphorus, used alone, has never been shown to be effective for manuring Gooseberries.

In Rhode Island, U.S.A., positive results were claimed from lime, but at Stoulton, Worcs., on an acid soil there was no clear evidence of benefit from a lime application, and it appears that Gooseberries are tolerant of fairly acid soil conditions.

Black Currants.—In all experiments in this country dung has proved an excellent manure for this fruit and generally superior to artificials, although the dressings in the cases where comparisons have been made have not always been strictly comparable. The fruit is doubtless less affected by potash deficient conditions than the Gooseberry, as was shown at Hadlow, where Black Currants did not respond to potash when applied with dung, and in the experiments at Long Ashton, Cannington, Perdiswell and in Europe.

It should be emphasized, however, that in experiments in this country, potassium has again proved the most important deficiency. Nitrogen deficiency is also clearly shown at Cannington under conditions where "omit nitrogen" treatment gives excellent results with Gooseberries and Strawberries.

Phosphorus again appears of little importance in the field.

Red Currants.—The outstanding feature in experiments on Red Currants has been the great susceptibility of the fruit to potassium starvation. It appears to parallel the Gooseberry in the drastic effects of this deficiency, but in the writer's experience at Hartlip and at other centres in commercial plantations, it has appeared to be slower in responding to potassic manuring.

At Hadlow it was found that Red Currants gave better results from complete artificials than from dung.

Results in Europe have strongly emphasized the need for potassic manuring and the damage which may follow from the use of chlorides, as in potash salts, this damage resembling potash deficiency effects in producing leaf scorch.

Markedly beneficial results were obtained from liming in experiments at Rhode Island, but no tests have been made in this country.

Raspberries.—At Woburn the results for Raspberries were similar to those for Currants, whilst at Hadlow it was concluded that heavy manuring was unnecessary and that potassium was of great importance.

At Cornell, nitrogen improved cane growth but only small increases in crop resulted.

At East Malling GRUBB's experiments demonstrated differential varietal responses and showed that generous manuring could not be relied upon to increase yields with all varieties. Later the more exact experiments of HOBLYN showed that potash was the first requirement for increasing crop yields ; shoddy produced increases in cane but not in cropping ; the importance of nitrogen/potassium relationships was shown and nitrogen was only advantageous when used with potassic manures ; sulphate of potash was superior in action to kainit which produced harmful effects in certain seasons.

At Perdiswell, in a plantation in which ' Pyne's Royal ' has grown and fruited well, potash deficiency effects have been clearly shown where this constituent has been omitted from the manurial dressing. Thus the English experiments all point to potassium as of first importance in the manurial programme, nitrogen increasing cane growth rather than yields.

In the U.S.A., where the importance of organic matter content of the soil and nitrogenous manuring is emphasized, positive results have been obtained from nitrogen when applied under advantageous conditions, but STENE has shown that in Rhode Island, contrary to general opinion, potassium has produced larger effects than either nitrogen or phosphorus.

Strawberries.—This fruit appears to be one of the most difficult with which to carry out experiments and results are difficult of co-ordination owing to the variability of systems of cultivation and the effects of different local environments. Nevertheless, there seems to be agreement on several points.

BEDFORD and PICKERING concluded that manures, either dung or artificials, had remarkably little effect on yields, though dung increased berry size and longevity of the plants.

At Hadlow results were again variable, but the conclusions were drawn that heavy dunging was unnecessary and that potash was not required with dung but in artificials it was very effective.

In early experiments in U.S.A., Strawberries responded to phosphorus, and at Cornell they were the only soft fruits to do so on some plots which were so poor in phosphate supply that corn would not form "ears." Results from nitrogen and liming were conflicting, nitrogen, in particular, being definitely injurious in some areas such as in Missouri.

Cover crops were advantageous in Oregon.

In experiments at Long Ashton, potash deficiency has been a limiting factor ; dung has been especially potent in increasing growth and yields ; shoddy has proved a good source of nitrogen and effects have been produced by complete artificials. In one experiment phosphorus deficiency has been apparent. It has been shown in these experiments that fertilizers definitely influence eating quality and chemical composition, dung and complete artificials producing rather watery types of berry, shoddy full flavour, potassium deficiency sub-acid conditions and phosphorus deficiency acid fruits with poor sugar content.

At Cannington potassium deficiency has also proved the most important factor and has led to almost complete dying out of the plants ; complete artificials have given the highest yields and wholly excellent results ; omitting nitrogen from the complete fertilizer, as in the case of Gooseberries, has given good results whilst, omitting phosphorus, although producing good growth, has resulted in relatively poor yields. This experiment thus shows that phosphorus may be important in Strawberry nutrition under conditions where it is relatively unimportant for Gooseberries and Black Currants.

Chemical results at this centre support the conclusions from the Long Ashton plots.

In LIERKE's experiment in Germany the results are in agreement with those at Cannington, potassium proving most beneficial, then phosphorus and nitrogen least effective.

In recent work in U.S.A., HOAGLAND and SNYDER have shown that Strawberries require boron for their proper development, and this may account for certain difficulties in practical nutritional and disease problems. They also showed that the fruit is susceptible to injury from sodium and chlorine, and from alkalinity produced by sodium bicarbonate. The latter results again indicate how easily the Strawberry plant may be adversely affected by soil conditions.

CLARK showed that the preference for sulphate of ammonia or for nitrate of soda depended on the acidity of the nutrient medium. DARROW has shown that potassium and phosphorus affect the acidity of Strawberry fruits in the directions observed in the Long Ashton experiments. With WALDO, this worker has also shown that in North Carolina large effects can be produced by nitrogen, phosphorus and potassium in fertilizers, but that, contrary to English results, nitrogen is the most potent. An organic form of nitrogen was found superior to nitrate of soda, which was liable to bring about injurious effects, especially in periods of drying winds. Over-manuring, by producing luxuriant foliage, resulted in decay of berries on the plants during wet periods.

Other experimenters have shown how nitrogen may be used to increase yields, and it has been demonstrated that firmness is decreased by nitrogenous dressings, though often not to appreciable extents commercially.

Finally, KIMBROUGH has shown how the effects of fertilizers may be quite overshadowed by such factors as drought and soil moisture during the fruiting season.

CONCLUSIONS.

General Aspects of Nutrition.

(1) Bush fruits present their own special nutritional problems, and analogies with those of tree fruits and of agricultural and horticultural crops cannot be pressed too far.

(2) Conditions for growth must be favourable in the spring and

early summer and an adequate supply of soil moisture is necessary during the fruiting season.

Effects due to soil moisture may be greater than those produced by manurial treatments.

(3) Bush fruits, in general, are tolerant of a fair degree of soil acidity, but calcareous soils are often conducive to lime-induced chlorosis, especially in Raspberries.

(4) The most favourable soils for bush fruits are usually loams of medium texture with fairly free drainage, and either slightly acid in reaction or containing small supplies of free carbonate of lime.

(5) The various classes of bush fruits differ in their soil requirements.

Gooseberries are tolerant of a wide range of soil conditions, providing drainage is adequate and potassium is not deficient.

Black Currants also flourish over a wide range of soil conditions and will stand wetter soil conditions than the other soft fruits. They grow particularly well on medium to heavy textured soils if the level of fertility is fairly high.

The soil requirements of Red Currants are, in general, similar to those of Gooseberries.

Potassium is usually the limiting factor where growth is not satisfactory.

Loganberries and Blackberries grow well on medium to heavy soils but drainage must be good.

Raspberries prefer light to medium textured soils, conducive of free rooting, and are particularly liable to " killing " on heavy soils during periods of wet weather.

Strawberries grow over a very wide range of soils, from poor thin acid sands and gravels to heavy clays, but very distinct varietal preferences are shown, certain varieties being very susceptible to soil wetness.

Manuring.

The different classes of soft fruits show particular manurial requirements, but in English experiments potassium has been shown to be the most important limiting factor to healthy growth in all cases. Deficiency of the element is usually aggravated by the use of purely nitrogenous fertilizers.

Gooseberries : potassium is of fundamental importance and produces the largest responses, and may even increase yields when used with dung. Dung usually produces large increases, much higher than any system of artificials, but under certain conditions must be used in moderation or the bushes become over-vigorous, leading to excessive shoot growth and decrease in crops. Nitrogen should be used with caution and phosphorus is usually of secondary importance and should be applied in moderation. Lime is of minor importance.

Black Currants : potassium is again important, but dung and nitrogen may be used more liberally than for Gooseberries without fear of excessive wood growth, and the use of these is associated with

the highest yields in various experiments. Phosphorus again has proved of less importance than potassium or nitrogen. In general, Black Currants may be said to respond more to liberal manuring and to be less liable to injury from excessive use of manures than any of the soft fruits.

The importance of liming has not been determined.

Red Currants: potassium is the pre-eminent requirement of this fruit and responses in the field may be slower than in the case of Gooseberries. Dung has not been shown to be superior to artificial manures.

This fruit appears to be especially susceptible to injury from chlorine-containing fertilizers such as kainit or potash salts.

Raspberries: potassium has consistently increased yields in manurial experiments in England, whilst nitrogen, which is regarded as of great importance in U.S.A., has usually increased cane growth but rarely affected cropping when used alone. Sulphate of potash is superior to chloride-containing materials such as kainit, which may cause injury. An adequate supply of organic matter in the soil seems beneficial.

High manuring is not advantageous.

Loganberries and Blackberries: experimental data are lacking, but observations point to similar requirements to those of the Raspberry. Both fruits are probably easily injured by excessive dressings of artificial fertilizers.

Strawberries: potassium is often a limiting factor under English conditions and phosphorus appears to be of importance. Strawberries seem to respond to phosphatic dressings more than any other soft fruit. Nitrogen requires to be used with caution. Dung and bulky organic manures such as shoddy give good results. Excessive dressings of artificials may cause damage.

The eating quality, firmness and chemical composition of the fruits are appreciably affected by dung and fertilizers.

References.

(1) Bedford, Duke of, and Pickering, S. U.: "Science and Fruit Growing." Macmillan, London, 1919.

(2) Chandler, W. H.: "Fruit Growing." Houghton Mifflin, New York, U.S.A., 1925.

(3) Cherry, W. F.: "Studies on the Effect of Chemical Fertilisers upon Growth and Fruit Production of the Black Raspberry." (*Proc. Amer. Soc. for Hort. Sc.*, p. 176.) 1933.

(4) Childs, W. H., and Hoffman, M. B.: "Nitrogen Fertilisation of Latham Red Raspberries." (*Ibid.*, p. 302.) 1932.

(5) Clark, J. H.: "Reaction of the Nutrient Medium as affecting Growth of Strawberry Plants." (*Ibid.*, p. 283.) 1933.

(6) Darrow, G. M.: "Effect of Fertilisers on Firmness and Flavour of Strawberries in North Carolina." (*Ibid.*, p. 231.) 1931.

(7) Darrow, G. M., and Waldo, G. F.: "Effect of Fertilisers on Plant Growth, Yield and Decay of Strawberries in North Carolina." (*Ibid.*, p. 318.) 1932.

(8) Dyer, B., and Shrivell, F. W. E.: "The Manuring of Market Garden Crops." Vinton, London, 1913.

(9) FISCHER, R.: "Versuche zur Bekämpfung der Blattranddürre der Johannis- und Stachelbeeren in Oesterreich." (*Die Ernähr. der Pflanz.*, xxviii, p. 440.) 1932.
(10) GAUT, R. C.: "Gooseberries: Manurial Experiment." (*The Worcestershire Agric. Quarterly Chronicle*, 1, 3.) May 1933.
(11) GAUT, R. C.: "Black Currants: Manurial Experiment." (*Ibid.*, 1, 2.) Feb. 1933.
(12) GRAM, E.: "Forsøg med Plantesijgdomme og Jordtroethed." (Abstract from *Tidsskr. for Planteavl.*, xxxvi.) 1930.
(13) GREVE, F. W., and SHOEMAKER, J. S.: "Relation of Nitrogenous Fertilisers to the Firmness and Composition of Strawberries." (*Proc. Amer. Soc. for Hort. Sc.*, p. 183.) 1930.
(14) GRUBB, N. H.: "Raspberry Investigations." (*E. Malling Res. Stn. Ann. Rept.*, p. 129.) 1923.
(15) HOAGLAND, D. R., and SNYDER, W. C.: "Nutrition of Strawberry Plant under Controlled Conditions: (*a*) Effects of Deficiencies of Boron and Certain other Elements: (*b*) Susceptibility to Injury from Sodium Salts." (*Proc. Amer. Soc. for Hort. Soc.*, p. 288.) 1933.
(16) HOBLYN, T. N.: "The Layout and Conduct of Two Manurial Trials of Raspberries: together with the Deductions which can validly be drawn." (*J. Pomol. and Hort. Sc.*, ix, p. 303.) 1931.
(17) JØRGENSON, C. A.: "Die Blattrandkrankheit der Johannisbeere." (Abstract from *Tidsskr. for Planteavl.*, xxxvii, p. 729.) 1931.
(18) KIMBROUGH, W. D.: "Strawberry Quality as influenced by Rainfall, Soil Moisture and Fertilisers." (*Proc. Amer. Soc. for Hort. Sc.*, p. 184.) 1930.
(19) KIMBROUGH, W. D.: "The Effect of Fertiliser on the Quality and on the Keeping and Carrying Qualities of Strawberries." (*Ibid.*, p. 224.) 1931.
(20) KNIGHT, LUCY D. M., and WALLACE, T.: "The Effects of Various Manurial Treatments on the Chemical Composition of Strawberries." (*J. Pomol. and Hort. Sc.*, 10, No. 3.) 1932.
(21) LIERKE, R.: "Düngungsversuche zu Obstbäumen und Beerensträuchern." (*Die Ernähr. der Pflanz.*, xxxiv, p. 248.) 1933.
(21A) OVERHOLSER, E. L., and CLAYPOOL, L. L.: "The Relation of Fertilisers to Respiration and Certain Physical Properties of Strawberries." (*Proc. Amer. Soc. for Hort. Sc.*, p. 220.) 1931.
(22) PROEBSTING, E. L.: "Absorption of Potassium by Plants as affected by Decreased Exchangeable Potassium in the Soil." (*J. Pomol. and Hort. Sc.*, xi, p. 199.) 1933.
(23) SCHOEVERS, T. A. C.: "Die sogennante Blattrandkrankheit bei Johannisbeeren und ihre Bekämpfung." (*Die Ernähr. der Pflanz.*, xxv.) 1929.
(24) STENE, A. E.: "The Fertilisation of Red Raspberries." (*Rhode Island Expt. Stn., Bull.* 229.) 1931.
(25) STENE, A. E.: "Preliminary Studies in the Fertilisation of Red Raspberries." (*Proc. Amer. Soc. for Hort. Sc.*, p. 276.) 1933.
(26) TAYLOR, R. W.: "The Influence of Winter Applications of Fertilisers on Strawberries." (*Ibid.*, p. 187.) 1930.
(27) TAYLOR, R. W.: "Influence of Nitrogenous Fertilisers applied at Different Dates on the Number of Flower Clusters, Flowers and Fruits of the Strawberry." (*Ibid.*, p. 313.) 1932.
(28) TURNER, A. D.: "A County Demonstration Plot." (*The Fruit Grower*, vol. 76, p. 804.) Nov. 9, 1933.
(29) TURNER, A. D.: "Manurial Deficiency Experiments on Strawberries." (*Somerset Farm Institute, Cannington. Advisory Report*, p. 137.) 1925–1934.
(30) VOGEL, F.: "Ueber die Bedeutung der Nahrstoffe und des Kali-Stickstoffverhältnisses bei der Stachelbeere." (*Die Ernähr. der Pflanz.*, xxix, p. 339.) 1933.
(31) VOGEL, F., and WEBER, E.: "Zur Blattrandkrankheit der Johannisbeere." (*Die Gartenbau*, v, p. 457.) 1931.
(32) WAGNER, F.: "Düngungsversuche bei Beerenobst 1907–1926." (*Arbeit. der Deut. Landwirt Gesell.*, Heft 377, p. 39.) 1931.
(33) WALLACE, T.: "Experiments on the Manuring of Fruit Trees, II." (*J. Pomol. and Hort. Sc.*, v, 1.) 1925.
(34) WALLACE, T.: "Field Experiments on the Manuring of Gooseberry Bushes." (*Ibid.*, vi, 3.) 1927.
(35) WALLACE, T.: "The Effects of Manurial Treatments on the Chemical Composition of Gooseberry Bushes, I." (*Ibid.*, vii, 1 and 2.) 1928.

(36) WALLACE, T. : " Experiments on the Control of Leaf Scorch on Red Currant and Gooseberry Bushes at Hartlip, near Sittingbourne." (*J. of the Kent Farmers Union.*) May, 1929.
(37) WEISKE, F. : " Ueber das Verhalten von Beerenobst gegen verschiedene Kalisalze." (*Die Ernähr. der Pflanz.*, xxvi, p. 269.) 1930.
(38) WENTWORTH, S. W. : " Effects of Nitrate of Soda on the Yield of Strawberries." (*Proc. Amer. Soc. for Hort. Sc.*, p. 358.) 1924.

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